Physicochemical characterization of spreadable liver paste and its main constituents

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Introduction

Spreadable liver pastes typically contain a significant amount of liver (proteins) and adipose tissue (lard fat). The functional behaviour of these constituents is expected to be important for the macroscopic properties of liver pastes. These macroscopic properties such as mouth feel, texture and stability are quality attributes of primary importance for the consumers' perception of liver pastes. To be able to control the quality of these products and eventually predict their macroscopic properties, it is necessary to characterize their microstructure and constituents. Knowledge of the relationships between these different structural levels will improve existing products and help in the development of new strategies to obtain clean label products or products with a healthier image (low-fat and/or low-salt liver pastes, liver pastes with healthier lipid formulation, etc.). Two mechanisms are generally proposed to explain the stabilization of fine emulsion-like meat products. Although an important role of the interfacial protein film has generally been accepted, no information is available about the importance of the physical entrapment theory in stabilizing liver pastes. The objective of this study was to gain insight into the macroscopic properties, microstructure and constituents of liver paste and to understand the relationship between these different structural levels, as this has not been studied before in liver pastes. This approach also allowed gaining insight in the mechanisms (emulsion theory and physical entrapment theory) involved in the stability of liver paste.

Materials and Methods

Four liver pastes were manufactured as reported by Steen et al. (2014). The content of liver and back fat and the salt level were varied, resulting in four different formulations: high and low liver/fat ratio, without and with salt (35/35 NS, 35/35 S, 20/50 NS and 20/50 S). The viscoelastic properties (G', G'', LVR [Linear Viscoelastic Region]) of the intermediates and the end product were characterized by dynamic oscillation experiments. The microstructure of the end products was studied by microscopy. Furthermore, the end products were analysed for emulsion stability (%TEF, %Fat) (Hughes et al., 1997), texture (Texture Profile Analysis, Bourne, 1978) and sensory mouth feel attributes 'creaminess', 'hardness', 'wateriness' and 'graininess' (QDA). The emulsifying (Pearce & Kinsella, 1978) and gelling (rheological temperature sweep) properties of liver protein fractions were investigated and compared to commercial protein ingredients (sodium caseinate, porcine globin and porcine albumin). Their molecular weight distribution (SDS-PAGE) and surface hydrophobicity (Kato & Nakai, 1980) were also studied. Two protein fractions were characterized: water soluble (WSLP) and water+salt soluble liver proteins (W+SSLP). The effect of different salt concentrations was also investigated (0, 1.8 and 3.4% NaCl). Differential scanning calorimetry and time-resolved small-angle X-ray scattering (SAXS) and wide-angle X-ray diffraction (WAXD) were used to study the isothermal crystallization formation mechanism of lard at 18, 20, 22 and 24°C.

Results and Discussion

For the conventional liver paste (35/35, 1.8% salt), liver proteins were present in the continuous phase and the fat globules were surrounded by a protein layer. G´ and G˝ of liver paste were higher in magnitude compared with both intermediates due to structure building during pasteurization and cooling. Generally,

the values of the viscoelastic parameters of liver paste batter and liver paste increased with the addition of salt. With salt, a stronger and more stable liver paste was obtained which may be attributed to solubilisation of salt soluble liver proteins, making them more available to act as emulsifier. A microstructure with smaller fat globules was obtained with the addition of salt, explaining the increased hardness and fat binding properties. A higher liver/fat ratio (35/35 versus 20/50) only increased the viscoelastic properties of liver paste batter while liver paste was not affected. This might be attributed to the crystallization of the fat in the liver paste with a high fat/liver ratio, which besides the structural potential of liver proteins, also contributes to the structure of liver paste. The micrographs showed a heterogeneous structure with bigger fat globules and fat channels with a decrease in the liver/fat ratio, causing decreased fat binding properties.

Regarding the functional properties of the liver proteins, both WSLP and W+SSLP displayed good emulsifying properties while their gelling properties were rather weak. An increase in salt concentration decreased the emulsifying properties of WSLP while the effect on W+SSLP was less pronounced. The gel forming ability of W+SSLP containing 0% NaCl was higher compared to this at high salt concentrations, probably due to a stronger intermolecular network of non-solubilized myofilaments compared to the network formed of more solubilized myofibrillar proteins at high salt concentrations. The same conclusions could be drawn for the WSLP, indicating that with phosphate solution also myofibrillar fragments were extracted as demonstrated by SDS-PAGE. Higher salt concentrations shifted the gel temperature of both WSLP and W+SSLP to lower temperatures. The effect of salt on the functional properties of liver proteins did not correlate with the results obtained in liver paste.

The WAXD and SAXS diffraction patterns showed that at 18 and 20°C, lard crystallized in three steps. In the first step, part of the melt (the trisaturated triacylglycerols (TAGs)) crystallized in α crystals adopting a double length structure (2L). In the second step, a polymorphic transition of these 2Lα crystals to β' crystals with a triple length structure (3L) occurred. Extra 3Lβ' crystals consisting of monounsaturated TAGs were also formed directly from the melt. In the third and last step, β crystals were formed due to a second polymorphic transition of trisaturated 3Lβ' crystals to β crystals adopting a 2L structure. Above a cut-off temperature of 20°C lard crystallized in two steps: no formation of α crystals could be observed and 3Lβ' crystals (trisaturated and monounsaturated TAGs) were formed directly from the melt. This proposed mechanism implies that lard crystallization is characterized by an overlap of fractionated crystallization and polymorphic transitions.

Conclusion

The results obtained in this work showed more insight in the microstructure and macroscopic properties of liver paste. In addition, it was demonstrated that liver paste is mainly stabilized by liver proteins surrounding fat globules. However, correlation of the functional behaviour of the constituents studied in model systems compared to liver paste was not evident.

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